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Gilbert G. Stamm, Commissioner

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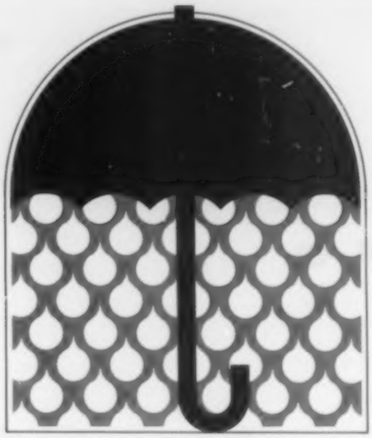


Total Water Management

by Richard W. Nash

Since its beginning 74 years ago, the Bureau of Reclamation program has become progressively multipurpose, evolving from a simple practice of putting water on the land to irrigate crops to using today's highly diversified and sophisticated program entitled Total Water Management.

The umbrella of Total Water Management (TWM) covers virtually every facet of water use and water supply. It can be as simple as lining a farm ditch to reduce conveyance losses, or as complex as desalting geothermal brines to create a new source of fresh water for the Lower Colorado River.

TWM involves identification and subsequent implementation of basinwide programs for conservation and improved efficiencies in water management and use, coordinated scheduling of river basin water storage and control works, salvage and reclamation of poor quality supplies, conjunctive use of surface and ground waters, augmentation programs, reallocation of water supplies to higher uses, and all other such practices that promote the fullest and highest use of a basin's water supplies.

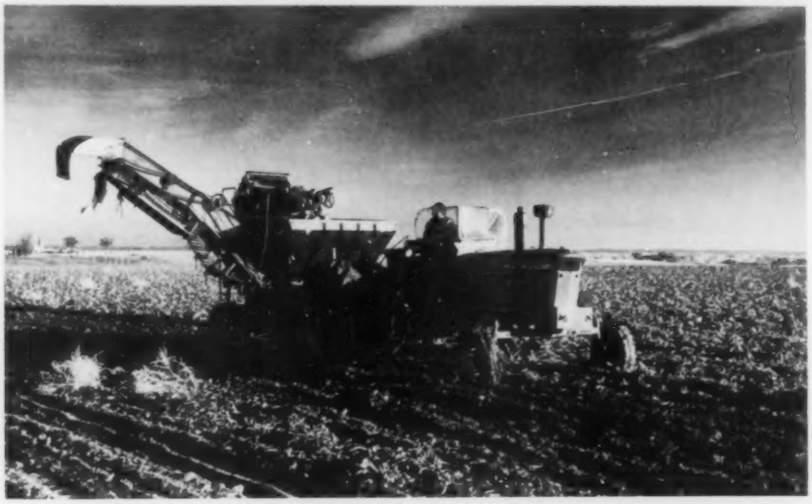
In this issue of the *Reclamation Era* several TWM activities will be discussed in detail—cloud seeding, water system automation, rehabilitation and betterment of projects and facilities, and irrigation management services.

The importance of TWM to the future of the West was emphasized by Commissioner of Reclamation Gilbert G. Stamm in a speech last August before a division of the American Society of Civil Engineers at Logan, Utah. He said:

"Today Reclamation is moving into the era of total water management—including sophisticated computer-controlled water augmentation programs such as cloud seeding and geothermal desalting, and water reuse and conservation programs to stretch available supplies.

Richard W. Nash is the Chief of the Program Coordination Branch, Division of Planning, Bureau of Reclamation, Washington, D.C.

Effective use of water will make more available for irrigation as for these sugar beets on the Colorado-Big Thompson project.



"It is these programs which offer the best hope of making certain that water is available to produce more energy, to grow more food, and to meet all the other increasing needs for water in the West today—and to do it in a way that doesn't harm the environment.

"For the total water management concept to be successful, it is essential that the local, State, regional, and national entities involved in a basin or area's water planning and development programs work in close cooperation. We are prepared to make that cooperative effort, and expect that total water management increasingly will become a most important means of satisfying new water demands in the West."

The TWM concept was given a further boost by the recently released "Westwide Study on Critical Water Problems Facing the Eleven Western States."

The Westwide report noted that "water planning and related planning must be a continuing activity in the West, even after the bulk of desirable water supply and regulation features have been constructed.

"With water so critical to the economy and the well-being of the western population, there will be a continuing demand for changes in use—technological advancements permitting more efficient and timely use—and for information to guide desirable institutional changes.

"Total water management planning, participated in by States and Federal water agencies, will become more and more the norm as the remaining water supplies of the West are dedicated to use," the report said.

The Bureau of Reclamation has a number of programs which fall within the TWM concept. In addition to the weather modification, geothermal, and irrigation management service programs mentioned earlier, the Bureau is actively underway with the Colorado River Basin Salinity Control project, which will ultimately improve water quality both in the United States and in Mexico.

The Colorado River Basin represents a classic argument for the necessity of total water management. Water in the Colorado River is already over appropriated in many States. In some areas, the water is of poor quality. Demands for all traditional uses are increasing, and now the Basin is faced with a new and urgent demand for water to develop its vast fossil fuel energy resources.

Meeting the projected demands for water in the Colorado River Basin will require an ambitious and visionary total water management program, including augmentation from weather modification, geothermal desalting, or perhaps a dual purpose sea water desalting and nuclear powerplant on the Gulf of California or Pacific Ocean.

There are other means of providing water in the Colorado River Basin, through mining of ground water, new storage opportunities, and exchange programs substituting ground water for Colorado River water in adjacent basins.

This woman is helping to test desalinization techniques at the Yuma Desalting Test Facility.

Water conservation and reuse programs are also an important part of total water management, and hold major promise as one means of using short water supplies more efficiently.

For example, 30 percent of the water diverted for use in the West is now being lost in transit—through percolation, evaporation, leakage—before it reaches the farm. Then, unfortunately, onfarm operations are no better than 40 to 45 percent efficient.

Not all of this, of course, can be considered a loss, especially in the case of upstream diversions, because some of the deep percolation returns to the stream and can be re-used. Nevertheless, opportunities exist to make more water available for beneficial use by improving management techniques and by upgrading facilities—through concrete linings or closed pipes in distribution systems, through more sophisticated controls on the farm and the conversion from present irrigation methods to sprinklers and drip irrigation systems.

Besides these broad programs, the Bureau will spend over $1.2 million this fiscal year for seven continuing or new total water management studies in specific river basins. These include studies in southwestern Idaho, the Upper Snake River area, Yakima Valley, Central Valley in California, the Lahontan Basin, the Elephant Butte-Fort Quitman area in New Mexico and Texas, and the Missouri River Basin upstream from Gavins Point.

Each TWM study must be tailored to the river system under investigation.

TWM studies are designed so they do not duplicate ongoing work of Federal and State agencies. The studies are being structured to maximize public input in the actual plan formulation process.

The studies include:

1. Determining the public's perception of its area's water and related land resource needs.
2. Selecting the priorities of critical and desired water- and land-related resource needs in the study area.
3. Examining available water supplies.
4. Analyzing efficiencies of existing projects and related improvement potentials, especially nonstructural improvements.
5. Using basin models and/or other up-to-date analytical procedures to evaluate the capability of alternative water supply systems in meeting the critical near-term and medium-term water requirements.
6. Evaluating and reporting on solutions to critical near-term problems and future projects that may contribute to meeting identified needs.
7. Evaluating and reporting on the hydraulic, environmental, social, and economic impacts of implementing a TWM program.

The objective of TWM studies within the Bureau of Reclamation is focused on a cooperative investigation of available water supply among interested Federal, State, and local agencies; national, regional, and local public organizations; and individuals. Its first priority is to determine how to improve the capabilities of existing and imminent water supply systems and related land uses through nonstructural modifications that minimize the requirement for new capital expenditures. Imminent water systems include those projects that are now being implemented and those that are authorized but unfunded. The first priority studies are directed toward meeting near-term (5-10 years) and medium-term (15-25 years) water demands in a river basin or sub-basin.

The umbrella of TWM covers virtually every facet of water use and water supply.

A report is prepared for each TWM study. The report contains data and information for use by decisionmaking bodies at all levels of Government. Some of the most important items in the report are conclusions of the study, recommendations for action and further study, priorities for action and study, the scope of work, and time and cost estimates for recommended actions and further studies.

Each TWM study must be tailored to the river system under investigation. The solution to problems of that system must be designed to fit the needs of the system. TWM requires that the public and associated Federal and State agencies have a voice in the development of each system. Their response must be requested at the planning stage.

Reclamation's TWM studies are essential in determining how to use our water resources wisely. By continuing with the studies of river basins and major subbasins, we should be able to secure the information that will help us make decisions beneficial to water users. And by insuring that the public has an input into the planning process, Reclamation will be doing its part in the proper use of our natural resources.

To some, TWM may appear to be a fairly easy proposition of simply balancing use with supply. However, it is not that clear-cut. Water must be distributed relative to time and area, because runoff and demand seldom coincide. The service area may not be located near the water source which requires the water to be regulated and transported. As a supply of water becomes fully committed and water use expands, a serious problem develops—how to allocate the water among different uses.

What is most troublesome in a large water management program is the maintenance of adequate supplies to meet each separate need. Water users must be assured dependable service. In large river-basin management schemes, greater overall efficiency is desirable, but quality service to the individual water user must be maintained. Where water supplies are ample, this is not too much of a problem. In areas where water is becoming fully committed and development of each project must be integrated with other projects, meeting the demand for an individual purpose at a precise time becomes increasingly difficult.

Reclamation will continue to pursue an aggressive TWM program in its evolving mission to put water to use for the benefit of people.

Reclamation is making real headway in assuring that quality service will be maintained for the individual water user through the use of computer scheduling, television monitoring, telemetry, better radio communication, and simulation techniques to improve designs and facilities.

Effective water management, when supplies are limited, can only be attained through coordination of authority, establishment of priorities, agreement on guidelines for development and management strategy, and cooperation among the distributor and the many water users. Over the years, Reclamation has been a leader in these areas working closely and effectively with local, State, and National leaders. Within its charter and the parameters set by the Congress, Reclamation will continue to pursue an aggressive Total Water Management program in its evolving mission to put water to use for the benefit of people.


The use of Geothermal water
is one way to augment water supplies.

A Look At Cloud-Seeding Research

by Wallace E. Howell

Wallace E. Howell is the Assistant to the Chief, Division of Atmospheric Water Resources Management, E&R Center, Bureau of Reclamation, Denver, Colo.

In any total water management program, water augmentation is an important element, and the Bureau of Reclamation's Project Skywater is a most important part of Reclamation's water augmentation program. Project Skywater is attempting to develop an effective and acceptable technology of precipitation management to help meet growing national needs for water resources.

Under Project Skywater, Reclamation has completed 13 experimental and pilot projects in field locations, is in the initial stages of one experimental project, and has one pilot project and one demonstration project in the planning stage. These projects all relate to one or the other of two meteorological-geographic situations where precipitation management appears most apt to advance soon toward wider and more effective application.

One setting is that of winter-orographic [1] precipitation in the Western United States. It is the source of most of the water used by agriculture, industry, and municipalities in that region. The second is summertime convective showers over the Great Plains, especially the subhumid western portion of that region (known as the High Plains), where water users in general and agriculture in particular are dependent on this highly erratic source of water and suffer from its unreliability.

One of the reasons that there has not been a more rapid and widespread acceptance of precipitation stimulation for water resources management and why the application of this technology has remained (in the United States, at least) a non-Federal activity, is that crucial scientific uncertainties still exist in the state of the art. Skywater research has decreased these uncertainties and is attempting to further reduce them.

Within the past 2 years, Project Skywater has completed six field experiments and two pilot projects dedicated to winter-orographic precipitation management.

[1] Orography is a branch of physical geography that deals with mountains.

Winter Orographic Field Projects

Location	Operating Dates	Purpose	Contractor
Jemez Mountains N. Mex.	1969-73	Verification of seeding concepts in New Mexico climate	New Mexico State University
Bridger Range Mont.	1969-72	Verification of seeding concepts in Montana climate	Montana State University
Elk Mountain Wyo.	1969-73	Cloud physics experimentation in cap cloud environment	University of Wyoming
Wasatch Range Utah	1971-74	Verification of seeding concepts in Utah climate	Utah State University
Cascade Range Wash.	1970-73	Verification of concepts for trans-mountain diversion of precipitation	State of Washington Dept. of Water Resources
Southern Sierras Nev.-Calif.	1969-70	Study of wide-area effects	Aerometric Research, Inc.
San Juan Mountains Colo.	1970-75	Pilot project trial of technical concept status	EG&G, Inc. (forecasts and seeding) WSSI (measurements) Aerometric Research, Inc. (evaluation) Colorado State University (ecology)
Basin of Lake Tahoe Calif.-Nev.	1970-75	Pilot project trial of benefit to Pyramid Lake	University of Nevada

While the results of some of these experiments were conclusive, others were not. But as in all scientific research, even the nonconclusive results guide us in where to go next.

The Bridger Range experiments in Montana indicated a positive effect in the class of test made when the seeding agent was carried over the target and the snowstorm was not a general one. Since, in this experiment, the seeding generators were very close upwind from the principal mountain ridge, it is believed that the seeding affected only the lower portions of deep cloud layers. The evidence fell short of meeting classical tests for significance.

Experiments conducted at Elk Mountain, Wyo., were designed primarily to test concepts regarding the number of ice-nuclei available in seeded and unseeded clouds and the concentration and rate of growth of the resulting ice crystals. The work has contributed substantially to improvement of computational models of precipitation formation.

The Cascade Range experiment in Washington State attemped to test the effect of snowflake size and concentration on precipitation. It is reasoned that if the snowflakes can be made smaller and more numerous, fewer will fall on the west side of the Divide and more on the east side. The evidence was obtained for a small number of cases. The next phase, that of proving the concept, awaits authorization and funding before entering the planning stage.

It is reasoned that if the snowflakes can be made smaller and more numerous, fewer will fall on the west side of the Divide and more on the east side.

In the Southern Sierras of Nevada and California, clouds were randomly selected to be seeded or to be used as control cases. Subsequently, precipitation was measured over a wide area downwind. The results showed significant increases from the seeded clouds, some exceeding 200 percent. In general, the larger increases were in valley locations having very low normal precipitation, so the absolute magnitude of the large percent increases was not economically important.

Two pilot projects also were conducted, one at Lake Tahoe and one in the Southern Sierras. Evaluation of the two pilot projects will be complete within a year.

Several conclusions regarding the findings of the experiments include:

—There are occasions when orographic precipitation is naturally inefficient because of the lack of sufficient time for natural precipitation to form within the cloud and to fall to the ground. On the other hand, there are occasions when artificial seed-

ing speeds up the formation and fall of precipitation enough so that the snowfall on the target area is significantly increased.

—There are occasions when precipitation is inefficient because the snow particles that form are too small.

—There are times when seeding causes additional precipitation to fall mostly on the windward slope of the mountain, and other times when the additional precipitation falls mostly on the leeward slope.

Environmental effects of winter orographic snowpack augmentation are, on the whole, slight. Most of them are too small to be discernible. Those that are discernible are mixed between positive and negative values.

Environmental effects of winter orographic snowpack augmentation are, on the whole, slight.

Harold Klieforth measures snow depth at Mt. Rose, Nev., after a recent snowfall.

The second type of water augmentation research, summer convective, includes the windup of five previous projects and the launching of the High Plains Cooperative Experiment (HIPLEX), involving planned research at three field sites. One of the previous projects in Texas is being modified and consolidated into HIPLEX.

The Cloud Catcher project at South Dakota School of Mines and Technology was the latest in a series of Skywater programs at that location. Using a computer-controlled radar as its principal observational tool, individual cloud events were selected for observation. For 1 hour the cloud was observed under computer process control and was tape-recorded. The radar-estimated rainfall from the silver iodide seeded clouds exceeds that from the unseeded clouds. The experiments left unanswered, however, the important question of whether the area-average rainfall was increased by seeding, since the increased activity in seeded clouds might have suppressed activity in other clouds nearby that would otherwise have rained more.

In the North Dakota pilot project one purpose was to tackle this unanswered question. In the four-summer project, a quarter of the days were reserved in advance as no-seed days. Of the remaining 277 days, 113 days were selected for seeding and others were left untreated. Analysis was based on rain gage measurements of rain on the ground. Subsequent analysis led the experimenters to conclude that rainfall increases resulted from seeding on days when the computer model predicted seedability, but not on other days.

The results showed significant increases, some exceeding 200 percent.

Some conclusions reached by researching summer-convective precipitation management include:

—Clouds whose growth is limited by stable air at some height in the atmosphere do not grow significantly larger in response to seeding.

—Clouds whose growth is not limited by stable air, but by other factors, grow significantly taller and process more moisture under the influence of seeding.

—Both the rainfall per cloud and the area-average rainfall are greater for seeded clouds of the class that grow larger under the influence of silver iodide seeding.

—There is strong evidence that clouds seeded with hygroscopic material yield heavier and longer-lasting showers than similar clouds not seeded. This conclusion, however, awaits confirmation by independent testing.

Summer Convective Field Projects

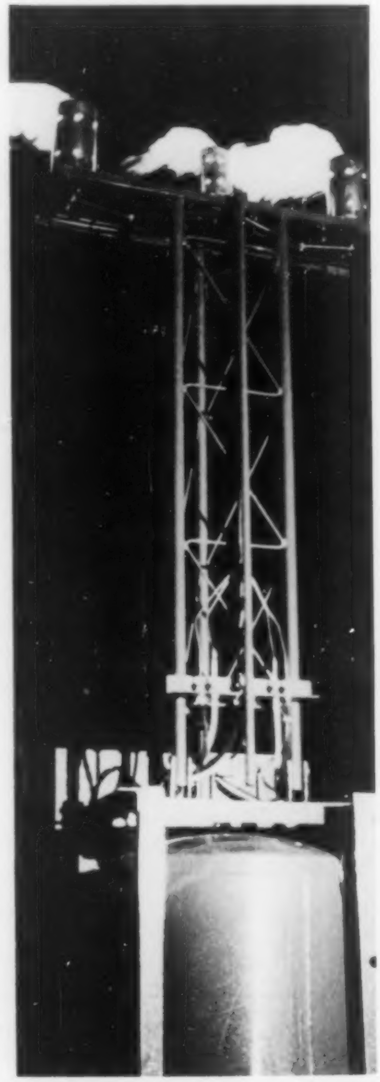
Location	Operating Dates	Purpose	Contractor
Southwestern South Dakota (Cloud Catcher)	1966-69	Radar documentation of precipitation development in treated and untreated clouds, silver iodide and salt treatments	South Dakota School of Mines and Technology (SDSM&T)
Western North Dakota (North Dakota pilot project)	1969-74	Estimating wide-area effects of seeding carried out for rain increase and hail suppression	SDSM&T
San Angelo, Tex.	1971-74	Radar and cloud-physics documentation of precipitation development in treated and untreated clouds	Texas Water Development Board (Meteorology Research, Inc. Subcontractor)
Western Kansas	1972-73	Estimating single-cloud effects of salt seeding	Sierra Research Corporation
Western Oklahoma	1972-75	Estimating single-cloud effects of salt seeding	Weather Science, Inc.
Montana	1972-73	Measuring transport of silver iodide from ground to cloud base	Montana State University
Miles City, Mont.	1974-	Comprehensive experiments on cumulus clouds and cloud systems for precipitation management	Convergence Systems, Inc.; Environmental Research and Technology, Inc.
Goodland-Colby, Kans.	1975-		

The HIPLEX program is the principal vehicle for future as well as current research by the Bureau of Reclamation in the realm of summer-convective precipitation. It is expected that emphasis will shift over the course of the first 2 to 4 years from concentration on individual clouds to investigation of the role of those clouds in cloud systems and how modification of systems should be managed. These studies will also include the possible effects of seeding over wider and more distant but continuous areas downwind from the principal study areas, and the environmental, social, and legal aspects of the technology.

As previously stated, the current work of the Bureau of Reclamation is in the areas of winter-orographic and summer-convective precipitation. These two topics do not by any means exhaust the possibilities that present themselves for future technology of precipitation management. Among the other weather situations that may be addressed in the future are the upslope precipitation systems that are common over the western Great Plains.

With the study of these two types of precipitation, the Bureau can learn much in its attempts to use our natural resources effectively and to make weather modification a part of a total water management program. era

This inspector checks the weighing bucket rain gage in the Cascade Mountains.



A silver-iodide generator burns through the night on a "seed-experimental" day.

Water

Quiz

1. The process by which water vapor escapes from the living plant and enters the atmosphere is called:
   a. infiltration
   b. transpiration
   c. precipitation
   d. evaporation
2. The phenomenon of water rising in a constricted space through molecular attraction is called ....
3. What is the process by which water sinks into the soil surface?
4. What is the name of the cycle that is the exchange of water between earth and atmosphere? What is the study or knowledge of water?
5. Fill in the blanks (same word). .... is the capacity of a solid to allow the passage of a liquid. The .... of soil or rock is determined by the number of pores, or openings, their size and shape, and the number of interconnections between them.

Answers to Water Quiz on page 32.

Infiltration, transpiration, precipitation, or evaporation?

New Developments in Local Downstream Control

WATER SYSTEMS AUTOMATION

by Edwin F. Sullivan

We expect those who supply water, gas, and electricity to our houses to respond immediately to our needs.

The "situation board" electronically displays pertinent current data on reservoir levels and contents, river stages and flows, diversions, and weather conditions.

Edwin F. Sullivan is the Assistant Commissioner—Resource Management, Bureau of Reclamation, Washington, D.C.

Water systems automation plays a particularly important role in applying the total water management concept to water supply systems. So much progress has been made recently in controlling the flow of water in canal systems that the conventional concept of scheduling water releases may become outmoded on many systems. Eventually a farmer may be able to satisfy the needs of his thirsty crops almost as easily as turning on a faucet in his house.

We expect those who supply water, gas, and electricity to our houses to respond immediately to our needs. It now appears possible to provide the same type of service for delivery of water to farmers' fields, as well as to municipalities served by conveyance canals. The technical name given to this concept is "demand operation." It is made possible by automatic downstream control. With downstream control, the water can be made available on demand for canalside turnouts with minimal prior scheduling.

With the conventional controls which regulate the flow of water in most irrigation distribution systems, it is necessary to order the water at least a day in advance. Canal operators must compile all of the water orders to determine the amount needed at each distribution point and then they must adjust the amount of water being released at the headworks of the canal, allowing sufficient time for it to arrive at its destination at the requested time. It may take hours and sometimes days for the new amount of water to travel along the canal. A ditchrider must follow the water as it flows downstream to open the canal gates, one by one, until the new flow reaches the desired location. Often, the ditchrider must revisit all the gates to make finer adjustments.

With automatic downstream control, it may be unnecessary to order water in advance, and the ditchrider will have time to attend to duties other than adjusting canal gates.

With automatic downstream control, it may be unnecessary to order water in advance.

Canals are divided into several reaches by a series of gates. Automatic downstream control uses a water level indicator at the downstream end of a canal reach to activate a controller, which in turn controls the gate at the upstream end of the reach. This indicator, sensing changes in the water surface level, provides a signal to the controller to adjust the gate opening automatically to restore the water level to a preset depth. Once the gate opening is changed, the indicator upstream from that gate will activate another controller to change the opening of the next gate upstream.

This procedure continues upstream to the canal headworks, resulting in all upstream gates rapidly responding to the initial change in water level. With all gates operating in this manner, there is no longer the need for an operator to adjust the gates. Downstream control is particularly appropriate for automating canals where deliveries are difficult to forecast, such as for municipal and industrial water supplies. Waste can be significantly reduced by increasing system efficiency.

The Bureau of Reclamation first became interested in applying downstream control in the 1960's. Through a research contract with the University of California at Berkeley, an investigation of the downstream control concept was sponsored. Additional research at the University and the Bureau of Reclamation led to the development of a controller called the Electronic Filter Level Offset (EL-FLO). Continued testing and development have resulted in a controller which not only automatically controls flow but also, either directly or indirectly, indicates alarm conditions such as high water, low water, gate limits, and loss of power or communications.

EL-FLO controllers have been installed on two canals in California—the Coalinga and the Corning.

At the Coalinga Canal, upstream control with local controllers and a regulating reservoir to eliminate waste was originally planned. Later studies indicated that downstream control eliminated the need for the planned regulating reservoir, resulting in substantial savings.

Water is diverted from the California Aqueduct and lifted 180 feet into the Coalinga Canal via the Pleasant Valley pumping plant. The nine pumps of different sizes have a total capacity of 1,185 cubic feet per second (ft^3/s). The canal is concrete lined and 11.6 miles long. The canal and pumping plant are operated by the Westlands Water District. Flow is controlled by gates at three locations. Both gravity and pump systems distribute water from the canal at nine different points, sharing common pumps.

EL-FLO controllers were installed during the summer of 1975 to control two gates. The third gate will be placed under EL-FLO control this year when pump controller equipment is installed at Pleasant Valley pumping plant. Although the two installed EL-FLO controllers appear to be controlling flow in a satisfactory manner, a complete evaluation of downstream control for the entire canal will have to await installation of the remaining control equipment.

During the first few years of operation when canalside demands were small, the Corning Canal was operated manually.

The Corning Canal, which uses water diverted from the Sacramento River near Red Bluff, Calif., is the other canal where EL-FLO control has been applied. Water is lifted 71 feet into the canal at the Corning pumping plant where six pump units of different sizes are housed. Some of the units are operated automatically to provide a flow which will approximately match the canalside demands. The Corning Canal is a 21-mile-long, earth-lined canal with a capacity of 500 ft^3/s. Canal flow is regulated by 12 gates spaced at intervals along the canal. The canal has 29 canalside turnouts. Twenty-six of the turnouts are pump type, of which seven are automatic. Most of the turnout valves to farmers' lands are operated by them.

During the first few years of operation when canalside demands were small, the Corning Canal was operated manually.

Manual operation was complicated by the addition of automated-pipe distribution systems having pressure-pipe laterals. These automated laterals are essentially demand systems, but their efficiency was limited by the capability of the canal to respond. Workers who manually operated the canal could not satisfactorily predict diversions and match canal flows to demands.

The first modification to aid operation was automation of the Corning Canal pumping plant and the settling basin, which is the intake for the pumping plant. Later, locally designed controllers were installed at all canal gates pending the development of the new method of automatic downstream control (EL-FLO controller).

After significant progress had been made in the development of the EL-FLO controllers, the equipment was installed to control all gates on the Corning Canal. The installation was completed late in the summer of 1975. The controllers appear to be working satisfactorily, but a complete evaluation will be made during the 1976 irrigation season.

Downstream control with the EL-FLO controller has received widespread attention. The Corning Canal is the United States "experimental project" in a joint research effort with the U.S.S.R. in the field of water resources—the Cooperative Agreement on Science and Technology, signed in May 1972. A 6-year joint program of research and development of automated water systems in each country has been agreed upon, and an exchange of visits and information has begun. The use of the Corning Canal as an "experimental project" will give the Bureau of Reclamation an opportunity to test and compare controllers and methods of controls under similar conditions. Thus, more meaningful comparisons may be made.

The Bureau of Reclamation has an ongoing water systems automation research program which includes investigation and development of many methods

Waste can be significantly reduced by increasing system efficiency.

Pleasant Valley pumping plant and intake channel.

of water systems automatic control. The development of downstream control methods and equipment is an important part of this program. Improvements to increase the reliability of the EL-FLO controller have already been developed and are being tested. New methods of downstream control are being studied. The Bureau has a contract with the University of California at Berkeley for the development of a new downstream control device. This device will include a very small, inexpensive digital computer which will improve the control system response.

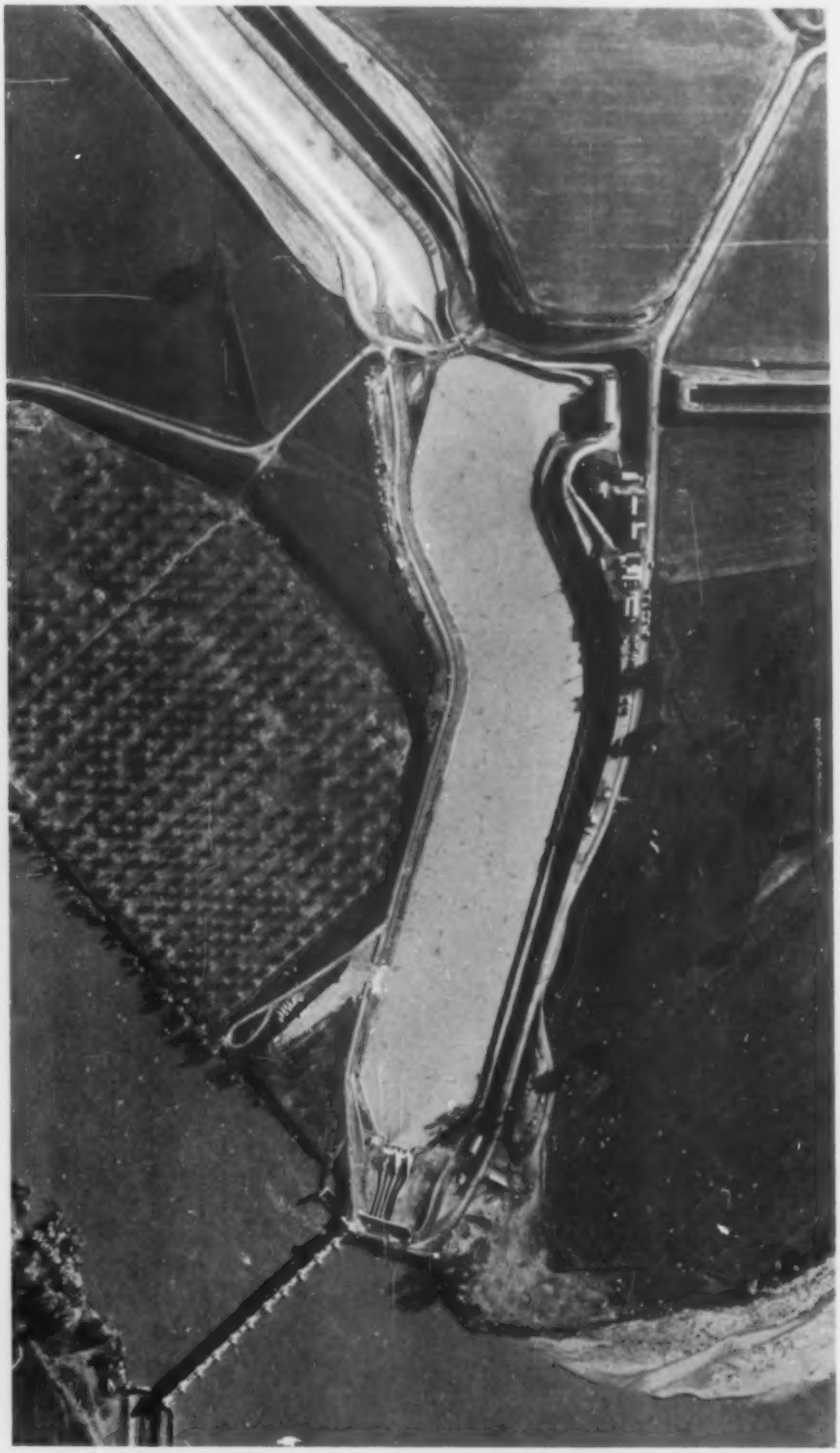
Automatic downstream control offers a method of canal control which has several attractive features when compared with other methods in the operation of many canal systems. Systems may be made so responsive that water may be supplied to the user on demand. Efficiency of operation may be increased so that much more water will be saved. Fewer and

Efficiency of operation may be increased so that much more water will be saved.

smaller regulating reservoirs may be required.

These, among other features, have attracted the attention of Bureau of Reclamation design and research engineers. The Bureau has taken significant steps to design and apply downstream control systems. Further improvements will be made to make even more responsive irrigation systems which will satisfy the needs of farms and municipalities. era

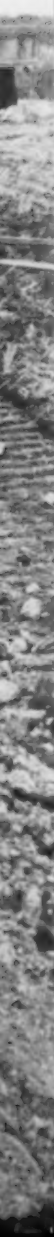
Red Bluff diversion dam
and stilling basin.



A check structure
on the Coalinga Canal.

Rehabilitation and Betterment

by E. C. Roper



This machine digs a trench, lays a perforated plastic drain pipe, covers it with a gravel blanket and refills the trench — a valuable machine to the R&B program.

Water is becoming an increasingly important commodity. Local government officials, industrialists, farmers, recreationists, fish and wildlife interests, environmentalists, and others are clamoring for a bigger share of that limited commodity.

Without water, none of these wants can be met. In fact, life as we know it could not exist.

Those having water rights are jealously guarding them, and many are seeking ways to acquire more rights. Consequently, it is incumbent upon all water users to utilize the water they receive in the most efficient and beneficial manner practicable.

Conservation of water is the responsibility of everyone—the Federal Government, the State, the irrigation and water districts, industry, municipalities, the irrigator, and even the individual municipal water user. Those organizations which deliver water to individual customers have a responsibility to help customers improve the efficiency of their systems and avoid unnecessary water and energy losses.

Many of the irrigation and drainage systems on Reclamation projects have been in operation more than 20 or 30 years, and some have been in operation for 60 or 70 years. Even though the best technology then available was used in the construction of these older projects, they are seldom as efficient as the projects we can build today.

Total water management must include a rehabilitation and betterment program.

In addition, deterioration and obsolescence have taken their toll. Unacceptable seepage losses result from unlined canals or from canals in which the lining has failed. Unreliable timber flumes and barrelstave pipelines are still in use, and deteriorated pipelines require constant repair. Obsolete or semioperative control structures prevent efficient control of water deliveries. Lack of adequate metering systems at key delivery points or at turnouts makes it impossible to distribute water equitably or efficiently. In many instances, costly repairs drain the district's funds which should be used for system improvement. Consequently, total water management must include a rehabilitation and betterment (R&B) program.

The Rehabilitation and Betterment Act, Public Law 81-335, approved October 7, 1949, and subsequently amended March 3, 1950, is designed to correct inefficient and unacceptable water collection, delivery, and distribution systems on Reclamation irrigation projects.

Public Law 94-102, approved October 3, 1975, expanded the coverage of the R&B program to include funds for the rehabilitation and betterment of projects constructed under the authority of the Small Reclamation Projects Act.

E. C. Roper is a General Engineer in the Division of Water and Land, Bureau of Reclamation, Washington, D.C.

The R&B program is administered by the Secretary of the Interior, through Reclamation, to facilitate the rehabilitation and betterment of irrigation and drainage systems on projects governed by Federal Reclamation law. The program is to cover repair, replacement, or improvement of irrigation structures. A program can be proposed if the cost of the work is more than can be funded by the reserves and annual revenues of the water users. However, it must be emphasized that need for an R&B program must not be the result of inadequate or improper maintenance of the project.

An R&B program must not be the result of inadequate or improper maintenance of the project.

The primary objectives of the R&B program are to improve existing irrigation systems in order to prevent physical failure of Federal irrigation systems and the economic and physical catastrophies that could result, and to reduce operation and maintenance costs, improve service, reduce water losses, reclaim waterlogged land, and improve the quantity and quality of drainage return flows.

Although there is no formal application procedure under the R&B program, guidelines have been established by the Department of the Interior for approval of R&B program applications. Action on a program may be initiated by Reclamation as a result of conditions observed during inspections conducted as a part of its continuing review of maintenance programs, or the district representing the water users can initiate the action.

There is no limitation on the total cost of the proposed work; however, the total cost must be repaid by the water users. An engineering and financial study must be made and a report prepared by Reclamation, the district, or a consulting firm employed by the district. A contract describing the work to be accomplished and the terms of repayment must be approved by the Secretary of the Interior.

Work contemplated under the program cannot be initiated until the expiration of 60 days after the proposal has been submitted to the Committees on Interior and Insular Affairs of the Senate and the House of Representatives unless, at an earlier date, both committees notify the Secretary in writing that the program is approved. Funds for the R&B program are secured through the normal procedures involving Congressional appropriations to Reclamation.

Through November 30, 1975, 90 R&B contracts were in force covering loans of approximately \$89.7 million. That amount does not include federally advanced funds which have been repaid. Four contracts covering loans of approximately \$3.3 million have been approved but have not been executed.

The recently approved R&B program for the Cascade Canal, Rouge River Basin project, Oreg., is an example of a program designed to reduce water losses from a canal as a result of rehabilitation. At present, seepage losses in the 11-mile-long canal are estimated to average approximately 40 percent. After rehabilitation, the losses from the canal are expected to average only 10 to 15 percent.

Use of the R&B program to improve the efficiency of an existing project is usually much less expensive than developing a new project. In any event, water for new projects is not available in most areas of the 17 Western States.

Unless a systematic R&B program is initiated soon, the productivity of many existing projects will drop drastically, and our Nation will be forced to develop more expensive alternative sources of water for irrigation.

Use of the R&B program will enable existing projects to continue making a contribution toward satisfying the ever-increasing national and international demand for food and fiber. Forecasts of work needed indicate that initial capital costs for irrigation systems eligible for R&B program loans could exceed \$100 million over the next 10 years.

Determining a beneficial use of waste water, as here on the Suisun Marsh, Calif., is an important element of the R&B program.

Additional experiments are conducted at the weather station of the Waste Water Reclamation and Reuse Pilot Demonstration Program for the Suisun Marsh.

Micro Kjeldhal conducts experiments on waste water.

Yesterday and Today in the ERA

Yesterday—1950

Shasta Dam, key unit of the Central Valley project of California, was officially "enlisted in the service of California and the Nation" in dedication ceremonies held before a large crowd at the east end of the dam, Saturday, June 17, 1950.

Officiating at the ceremonies was Assistant Secretary of the Interior William E. Warne, who dedicated the massive structure to "the people who helped make California great."

As he finished speaking, he cut a blue and gold ribbon, and the three huge drum gates atop the spillway section of the dam rolled down. A churning cascade of water poured over the gates and into the Sacramento River below.

The occasion was the climax to the week-long Shasta Centennial Celebration, in observance of California's 100th anniversary of statehood.

The previous evening, an informal program was held at the dam before 15,911 persons. At this program the manmade waterfall, three times the height of Niagara, was illuminated with batteries of giant searchlights.

Adding spice to the program were such entertainment stars as comedian Danny Kaye, Metropolitan Opera soprano Florence Quartaro, and movie actor Leo Carrillo.

A spectacular fireworks display from a barge on Shasta Lake capped the performance.

This was the moment that thousands of northern Californians, who watched the huge dam grow foot by foot, had been waiting for.

As Assistant Secretary Warne cut the ribbon, awed spectators watched the mighty waterspout which symbolized precious water for use by the Sacramento and San Joaquin Valley farmers.

For them, the event was more than a mere dedication. It meant that before long, water—the most important of California's vast natural resources—would be available for the parched lands of the State's greatest agricultural area.

Shasta Dam.

Today—1975

Today, Shasta Dam along with other major units of the Central Valley project is making preparations for the implementation of a centralized computer system, which is to monitor and control water, power generation, and power transmission facilities of each unit.

The master computer, which will be connected with computer facilities at each unit, will be located at the Central Valley Operations and Control Center in Sacramento, Calif. The system will provide a communication network among units, allowing for improved coordination and management of resources in the Central Valley project.

The computer facilities at Shasta, capable of handling the total system, will be a backup to the master computer. The system is expected to be in operation by spring of 1978.

At Shasta, another improvement that is expected to be completed within a year is moving the controls from station service units, which are separate from the central control room, into the central control room. By moving these controls, one man will be able to perform duties which now require two.

The dam, located near Redding, Calif., provides flood protection for rich, low-lying farm lands that line the Sacramento River. It also supplies irrigation water to these areas, which, because of their crop production, have a major impact on the economy of the State of California.

Shasta Lake, lined by the mountains of northern California, lures people to participate in the many recreational opportunities which exist there. These include swimming, boating, water skiing, and fishing. According to James Hamlin, Chief of the Shasta Field Division, Shasta Lake is a major California recreation area.

The dam allows for year-round navigation of the Sacramento River, and by maintaining a consistent flow of the river, prevents the waters of San Francisco Bay from encroaching on Sacramento River delta lands.

Electricity generated at Shasta is used to operate Central Valley project pumping plants such as Tracy, O'Neill, and San Luis. The electricity is also used by the cities of Redding and Sacramento.

In keeping with the concept of total water management, the Bureau of Reclamation, in cooperation with the Agricultural Research Service of the Department of Agriculture, is developing a program which will provide the tools and concepts to improve irrigation efficiency and project operation.

This program is called Irrigation Management Services (IMS). The purpose of the program is to encourage efficient use of our natural resources by irrigated agriculture. This program is expected to result in significant regional and national environmental benefits as well as economic benefits to irrigators and irrigation districts.

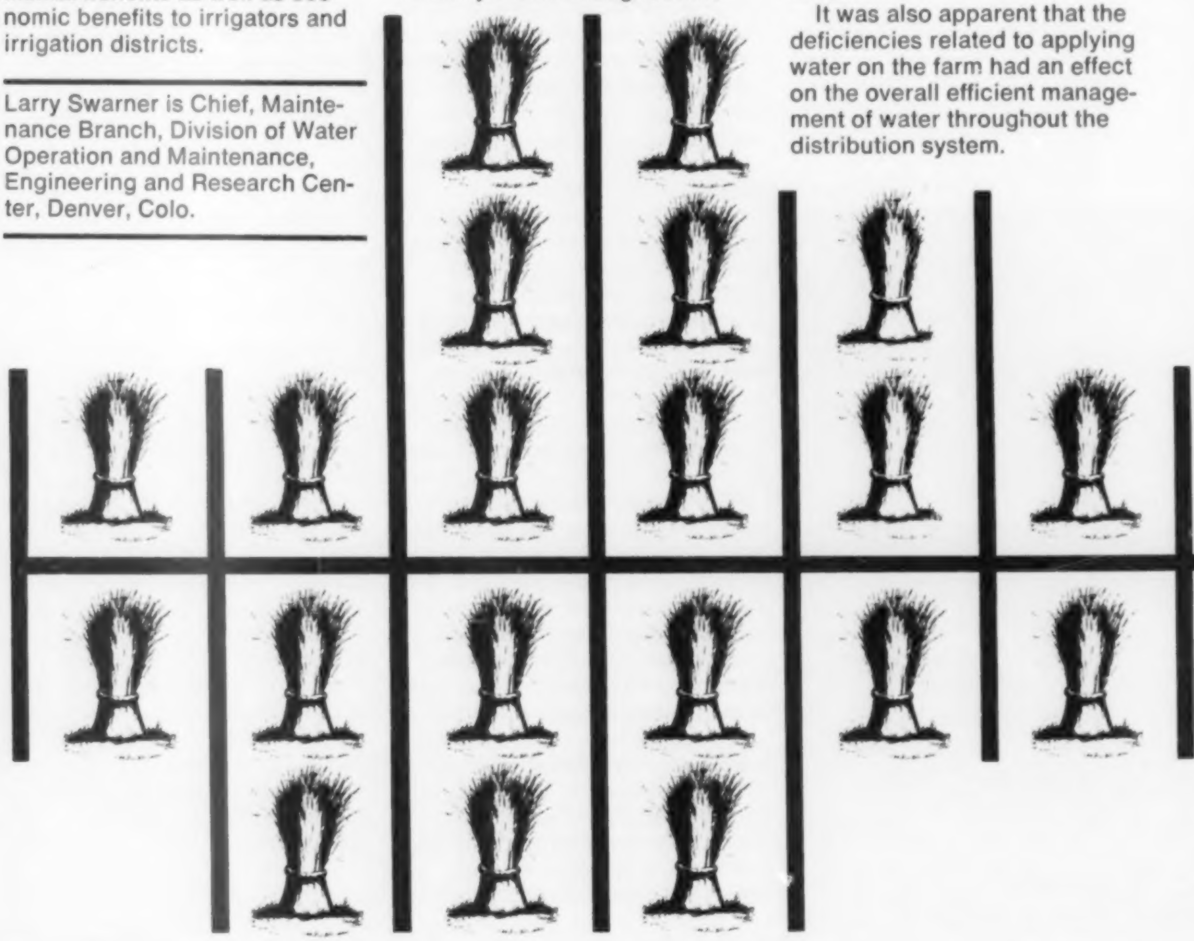
Larry Swarner is Chief, Maintenance Branch, Division of Water Operation and Maintenance, Engineering and Research Center, Denver, Colo.

It has been estimated that irrigation of crops accounts for approximately 80 percent of the water consumed in the 17 Western States. As competition for available water supplies increases, the irrigation industry is being challenged in some areas by municipal and industrial users who are able to pay more for these supplies. Therefore, it is essential that the irrigation industry of the West become more efficient in its use of water.

The IMS program is the outgrowth of studies made a few years ago by the Bureau of Reclamation on 300 farm fields in 18 study areas throughout the irrigated West. Researchers wanted to know what was happening in the water-user districts and on farms where the water was being used.

These studies were very revealing and showed that even when the total water applied during the irrigation season was greater than that necessary to produce good crops, often the crops suffered from a lack of moisture during the critical growing period. The studies further revealed that, as a general rule, the irrigator did not know when or how much water he should apply to fill the rooting zone.

It was also apparent that the deficiencies related to applying water on the farm had an effect on the overall efficient management of water throughout the distribution system.



Probably the most important conclusion drawn from the study was that before any substantial change in irrigation and water delivery practices can be expected, the irrigator will need to have better information as to when he should irrigate a particular crop and how much water he should apply. Along with this information, he will need technical assistance in applying the proper amount of water uniformly over the field. When better farm irrigation management is achieved, the project distribution system also can be operated more efficiently.

The IMS program includes the development of a plan by the Bureau of Reclamation for individual irrigators. The plan provides the irrigator with information on when he should irrigate and how much water he should apply. At the same time, information about the farm water demands is provided to operators of the water district to allow them to schedule water effectively throughout the distribution system.

The purpose of the program is to assure effective use of our natural resources by irrigated agriculture.

Basically, the program involves keeping a water budget for each field being irrigated. The amount of moisture in the soil at the start of the growing season is measured. As the season progresses, the amount of moisture used or "withdrawn" by the crop will be computed periodically from climatic data such as temperature, solar radiation, and wind movement. Deposits to the water "account" will be rainfall and irrigation water stored in the rooting zone. At any time, an updated budget analysis can show the amount of moisture in the rooting zone for a particular field and will predict when that field should be irrigated. The analysis will also indicate how much water should be added to the field during irrigation.

IRRIGATION MANAGEMENT SERVICES

by Larry Swarner

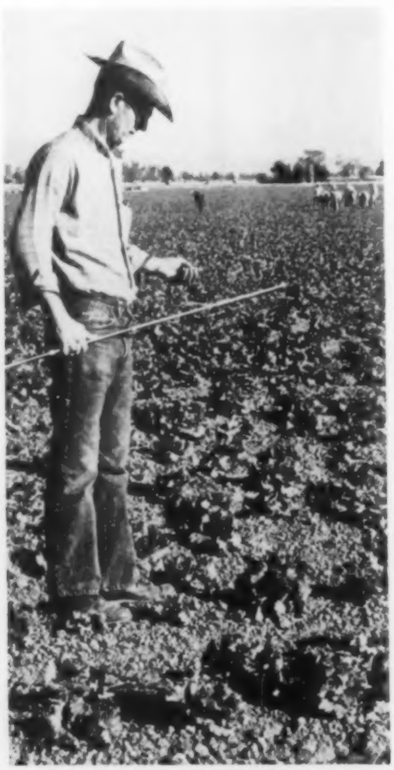
As the water "account" is used, the water-user will be notified of the time to irrigate and the amount of water to apply. The water districts' operators will also be apprised of the farm's demands. Based on crop development and climatic data from past years, an estimate of the irrigation date will be made in advance of the actual date. This estimate will be reconfirmed or updated once or twice a week with current climatic data so that the best irrigation date can be pinpointed. Because of the large amount of data required for many fields and the need for frequent updating, computers and data-handling systems are being used. The use of the computer makes it possible to carry out the program on a large number of fields and to coordinate scheduling demands at the farm with the scheduling of water deliveries throughout the distribution system.

Once irrigation scheduling is developed, the farm data are used to schedule water deliveries throughout the distribution system and on to the storage system. Thus, the IMS program is integrated into the regular ongoing operation and maintenance program of the water-users' district.

The Bureau's plan is to develop and demonstrate the program working with the water districts in cooperation with the Soil Conservation Service and the State Extension Services. Once the program is demonstrated and is operating in a water district, the district will take over administration of the program, including financing. The district has the option to conduct the program with its own personnel or to contract with commercial irrigation scheduling services. At this point, only limited technical guidance would be provided by the Bureau.

Because of the large amount of data required, computers are being used.

The IMS program seeks to improve irrigation management on farms.



Keith Milam takes a soilometer reading at the Region 10 Weather Station.

During the 1974 irrigation season, the Bureau demonstrated the IMS program in cooperation with water-user districts on approximately 309,000 acres on 20 operating projects. The Bureau's program also played an important part in enabling commercial irrigation scheduling services to provide scheduling service to approximately 250,000 additional acres during the 1974 season.

In 1974 the IMS program was demonstrated on 20 operating projects.

Improved irrigation management will have economic benefits for farmers, irrigation districts, and the Nation. Although limited documentation has been secured regarding these benefits, it is reasonable to expect that the major advantages for the irrigator are:

1. Increased crop yields and quality
2. More efficient use of labor
3. More effective use and saving of water
4. Reduced leaching of plant nutrients
5. Reduced drainage requirements

Benefits to water-user districts are:

1. Improved forecasting, scheduling, and control of irrigation water deliveries
2. More efficient use of water conveyance and distribution systems
3. Reduced diversion and pumping requirements
4. Reduced water demand during periods of peak evapotranspiration
5. Reduced maintenance requirements

Potential benefits to the region and Nation are:

1. Improved economics of irrigation agriculture
2. Reduction of adverse environmental impacts of irrigation agriculture
3. More efficient use of land and water resources

The moisture 'bomb' is used to measure soil moisture percent.

The IMS programs should help align irrigated agriculture with our national environmental goals. The program is a management tool for operating the total irrigation enterprise and provides a means for efficient and optimal operation of the irrigation project from the farm turnout, through the distribution system, to the storage facilities.

Information available thus far shows that the development of the IMS program is economically

The IMS program is economically worthwhile and environmentally sound to the irrigator, the water-user district, and to the Nation.

worthwhile and environmentally sound for the irrigator, the water-user district, and the Nation.

John Williford measures out moisture release samples.

After moisture extraction has been completed, release samples are ready to be weighed and dried in the oven.

News Notes

Departmental Honor Awards Convocation

Seven Bureau employees were honored at the Forty-third Honor Awards Convocation of the Department of the Interior.

Five men received Distinguished Service Awards.

H. E. Horton, Assistant Regional Director for the Mid-Pacific Region, has displayed exceptional engineering and administrative skills. He has played an important role in developing and promoting a unique Federal and State spirit of teamwork in building, operating, and maintaining the vast Central Valley project.

Dr. Archie M. Kahan, Chief, Division of Atmospheric Water Resources Management, Engineering and Research Center, directs the Bureau's atmospheric research program. Largely through his efforts, weather modification has advanced from a relatively untested and unappreciated science to a recognized technology with growing public acceptance.

Melvin A. Jabara, Chief, Hydraulic Structures Branch, Division of Design, Engineering and Research Center, has had an important influence on Bureau water resource facilities designs. His designs for spillways, outlet works, and other structures associated with dams have contributed significantly to design technology for these hydraulic features.

Clifford A. Pugh, Projects Manager of the Arizona Projects Office, has had a significant and lasting impact on water resources development in the Southwest. He was the primary administrator, planner, and engineer who guided the Bureau's efforts which culminated in the recent beginning of construction on the Central Arizona project. Under his skillful direction, the "Pacific Southwest Water Plan" and the plan for the Central Arizona project were formulated.

Edwin F. Sullivan, Assistant Commissioner—Resource Management, was recognized for his eminent service as an engineer and administrator. He had a prominent role in developing and implementing water-resource-oriented projects, particularly in the Bureau's Mid-Pacific and Pacific Northwest Regions. He was a key figure in formulating water and power policies during the early days of the Central Valley project in California.

The Valor Award was awarded to Donald W. Fisher, Chief, Security and Safety Division, and Arthur T. Carberry, Security Policeman of Hoover Dam, for their bravery. They rescued a woman from a treacherous rock ledge on the Nevada canyon wall approximately 35 feet from the top of the canyon and 625 feet above the Colorado River. Their courageous action in saving a life involved a high degree of personal risk.

Answers to Water Quiz:

1. b. transpiration
2. Capillarity
3. Infiltration
4. Hydrologic cycle. Hydrology
5. Permeability

Bureau Projects Make Record M&I Water Deliveries

Reclamation projects supplied a record 738 billion gallons of water to cities, homes, and industries in the 17 Western States during 1974.

The 1974 increase in domestic and industrial water deliveries was a continuation of the steady increase that has taken place since 1960. During this period, the annual delivery of water for nonagricultural uses has almost doubled.

Total deliveries of nonagricultural water for 1974 represented an increase of 17.6 billion gallons over 1973.

About 616 billion gallons of water were delivered from Reclamation facilities to help meet the water needs of 15.8 million people. Water deliveries for other nonagricultural uses such as irrigation of urban and suburban lands, water for livestock, fish and wildlife, and domestic farm uses totaled 122 billion gallons.

The Boulder Canyon project on the Colorado River, including Hoover Dam and Lake Mead, led all other projects in terms of population served and total municipal and industrial water delivered.

Arthur T. Carberry and Donald W. Fisher

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